WORKING PAPER | JANUARY 2022

TVET Skills in the South African Green Hydrogen Economy: A Policy Review

MUHAMMED PATEL, TRADE AND INDUSTRIAL POLICY STRATEGIES (TIPS)

DEON CLOETE, SOUTH AFRICAN INSTITUTE OF INTERNATIONAL AFFAIRS (SAIIA)

SOUTH AFRICA UK PACT

SAIIA 90 YEARS EST. 1934

Acknowledgements

A working paper produced by Trade and Industrial Policy Strategies (TIPS) and South African Institute of International Affairs (SAIIA) for submission to UK PACT Output 2.5.

Research consortium partners:

Key stakeholders and primary beneficiaries represented on the steering committee:

Table of Contents

Figures

Tables

Introduction

South Africa is at a crucial juncture in its developmental trajectory. With the ambitious and growing interest in green hydrogen as an energy source and carrier, numerous opportunities open up for the country in order to usher in a new and sustainable developmental pathway. State policies will play a key role in guiding this development and globally countries have already initiated the policy and regulatory framing and intentions. The policy responses cross the domains of industrial policy, energy planning, and education and skills development.

As a feature of economic history, new markets typically displace incumbent or obsolete methods of production. Within the broader context of the energy transition, renewables, green hydrogen and other sustainable energy production methods seek to reduce the carbon-intensive nature of fossil-based energy systems. Here coal is the most notorious among the fossil fuels and happens to be the principal source of energy generation in South Africa. As South Africa's departure from coal has already manifested through energy planning and coal decommissioning, grappling with the impacts of coal departure is another major developmental challenge that has to be navigated. Here the discussion centres on the Just Transition (JT) as it relates to energy systems. The central idea of the JT seeks to mitigate the impacts of climate and policy on vulnerable stakeholders and place them in a context where they are better off after the transition. Here the development of the green hydrogen value chain has a role in absorbing displaced labour and contributing to the economic diversification of coal-reliant municipalities and communities. The development of a domestic green hydrogen value chain can not only play a role in driving new employment but also transition workers from industries facing long term decline, such as coal.

This paper seeks to shed light on the policy dynamics that pertain to the green hydrogen value chain. Section 2 takes stock of the evolving green hydrogen landscape in South Africa. Section 3 turns to the typical trajectory that countries follow in terms of market development. Section 4 reviews international approaches to green hydrogen policy development in the arenas of industrial policy, energy planning, and skills and training development. Where just transition policies are relevant, these are included in the discussion. Section 5 then turns to a policy discussion for South Africa assessing policy interventions that can aid in growing the domestic green hydrogen value chain to enable a well governed industry skills demand and TVET graduate supply ecosystem.

It is acknowledged that the policy space in South Africa is rapidly evolving with policymakers currently grappling with presenting a cohesive and coordinated approach to planning. The report is structured on the basis of the currently available public information combined with stakeholder interviews.

Building economic wellbeing and anticipatory governance in the TVET sector

The COVID-19 crisis has exacerbated South Africa's education systems and demands urgent priority to re-imagine post-school education and training in the context of global climate change, economic crises, and technological disruption through the 4th industrial revolution (4IR). According to Keri Facer,[1] it is time to find common ground in the longstanding debate on education's role in the economy. The dichotomous debate is predicated by one side on the idea that education is about equipping young people to attain jobs in a competitive global marketplace. While on the other side it is argued that education should help young people develop relationships and capabilities to thrive in society. Accordingly, Facer (2021: 2) argues it is now time to find common ground and to ask a more appropriate question, namely: "what sort of education will enable young people to create long-term economic wellbeing for themselves, their families and their communities?" Economic well-being here refers to the personal and collective ability to mobilise economic, social and material resources to achieve personal and collective wellbeing.

Economic wellbeing depends upon four forms of provisioning:[2]

- Paid work (the economy)
- Household provisioning (care for person)
- Provisioning of the commons (viable ecosystem)
- Provisioning by the state (infrastructural resources for other three)

Facer explains that the four forms of provisioning aim to not only create the conditions for dignified labour, but also to strengthen capacities for care and material autonomy, defence and care for local and global commons, and make state provisioning practices work for human dignity and planetary flourishing. This endeavour cannot be achieved on an

[1] Facer, K. It's not (just) about jobs: Education for economic wellbeing. Education Research and Foresight Working Paper 29. Paris, UNESCO, (2021).

[2] Facer, K. "It's not (just) about jobs: Education for economic wellbeing"

individual level or by states by thinking about jobs alone. The systemic understanding of economic wellbeing places emphasis on broader provisions than traditional paid work – what we tend to think of as 'the economy', or 'the market', namely, forms of employment and exchange. This might include resourcing households with money and/or goods with exchange value. This might be both formal work acknowledged through taxation and by the state – or informal work, providing access to money and/or goods in the grey economy.

Economic wellbeing is interrelated with household provisioning – this is the work within households that provides care for the person: the labour of looking after children and older adults; the production and preparation of food; for many women and children in areas of ecological stress, the gathering of water; or the creation of safe shelter to live within. This labour is essential to the capacity of the body to take on paid work. The systemic understanding of economic wellbeing also includes the provisioning of the commons – this references the resources that are held in common by local and global communities. This includes, for example, access to clean air, water, trustworthy sources of information, common lands for food production, a viable ecosystem that sustains agricultural production. These resources create the conditions for all other forms of provisioning, their sustenance is therefore economically critical.

Economic wellbeing cannot be achieved without the provisioning by the state – this references the infrastructural resources such as transport systems and roads, welfare and health care, or long-term research and development, legal rights and freedoms – which create stable conditions to enable the effective functioning of the other three forms of provisioning.[3] The domain of formal employment and 'the market' is deeply embedded in and dependent upon the provisioning activities of these three other domains: the household, the commons, and the state.

The TVET sector in South Africa perpetually functions without a systematic approach to foresight and a systemic-based approach for enabling governance to cope with accelerating, complex forms of change. The vocational skills system have negligible institutional systems to deal with the long-range time horizons or with the effects of near-term decisions on the longer range. Policymakers are often overwhelmed by prevailing issues, obsessed with

[3] Raworth, Kate. "Doughnut economics: seven ways to think like a 21st-century economist". Chelsea Green Publishing, (2017).

political ideology and tend to minimise the importance of longer-term futures in exchange for current circumstances. At cabinet-level, governments often have dedicated policy planning units, these units are not interconnected to communicate with each other, which in turn leads to a lack of overall policy coordination and disjointed African governance systems. Other similar developing countries are doing much better at developing and executing long-range policy, leaving South Africa in a perpetual state of being out-planned, out-paced and grossly vocationally unskilled for the current industry skills demands. In general, the notion of skills anticipation is too narrow and should encompass a range of issues to assure a flourishing society with a well-skilled workforce. The narrowness in traditional skills planning might be due to skills anticipation methods unable to account for the broad range of possible disruptors in the social, technological, economic, environmental, political and cultural values spheres.

The South African government and TVET sector lack the capabilities required to build anticipatory governance in vocational skills systems. Building anticipatory systems in governance structures will require a reimagining of the role of government and governance in the region and society. Decisionmakers need to grow personal capabilities to navigate uncertain technological futures over extended timeframes. This will allow government structures to co-create future-orientated innovative governance responses to better anticipate emerging complex challenges that are fit for purpose in a post-normal era.

The many meanings of anticipatory governance[4] include:

- The ability of a system to use a certain set of data to determine possible future scenarios, or shape and implement a future vision based on forecasts and knowledge.
- The incorporation of participatory measures for goal setting and ensuring feedback loops for monitoring and evaluation.
- The swift exploitation of links (compared to conventional government structures) between role-players to benefit many.
- The dismantling of bureaucratic hierarchies and devolution of powers
- A system of systems, guided by rules and norms that enable foresight, networks and feedback to reduce risk and increase capacity to respond to events at earlier rather than later stages of development.

Anticipatory governance allows "a region, whether city or state, to harness the collective intelligence and wisdom of collaborating organizations and citizens, to deal with strategic risks and leverage emerging opportunities for meeting development goals. It is an approach

[4] Leon Fuerth, *"Foresight and Anticipatory Governance,"* Foresight 11, no. 4 (2009): 14–32; Jose Ramos, Ida Uusikyla and Nguyen Tuan Luong, *Anticipatory Governance – A Primer* (Vietnam: UNDP, 2020). https://www.vn.undp.org/content/vietnam/en/home/blog/AnticipatoryGovernance.html

for ‘social navigation’ — the ability for a society to navigate the complex terrain of social change.”[5]

The TVET policymakers need to interrogate the practical capabilities and systemic innovations to build vocational skills systems of institutions, rules, and norms that provide a way to use foresight, networks, and feedback to reduce risk and increase capacity to respond to industry demand at earlier rather than later stages of development. Building anticipatory governance in the TVET sector will mean that decisionmakers will be able to register and track events that are barely visible at the horizon; tap into their ability to self-organise to deal with the unexpected and discontinuous; adjust rapidly to the interactions between current policies and complex emerging problems; adopt collaborative and participatory processes and systems for exploring, envisioning, direction setting, developing strategy and experimentation for vocational skills systems; and enable the South African TVET system, to harness the collective intelligence and wisdom of collaborating organizations and citizens to deal with strategic risks and leverage emerging opportunities for meeting development goals.

The evolving South African green hydrogen landscape

Value chain development

The current input manufacturing space in South Africa has been developing rapidly, with a number of projects underway to increase domestic production of electrolysers and fuel cell systems that are used in hydrogen-based production and consumption. Current and emerging firms in the South African landscape include HyPlat, Isondo Precious Metals, Hydrox holdings, Bambili Energy, Chem Energy SA, and Mitochondria Energy. The Proton Exchange Membrane route which uses a platinum catalyst is seen as advantageous for South Africa since the country holds the largest platinum reserves in the world and the PEM route is currently the popular technology of choice. Firms at this stage of the value chain supply input components and full electrolyser and fuel cell systems to a number of

[5] Ramos, “Anticipatory Governance - A Primer.”

downstream firms that include domestic hydrogen producers, telecommunications firms, electricity producers, automotive firms and serve the growing export market.

There is currently no commercial green hydrogen production in South Africa and existing hydrogen production occurs via fossil fuel-based routes. A number of industrial players producing fossil fuels-based hydrogen have however indicated an interest in reducing their carbon emissions and supplementing with green hydrogen production in the short to medium term (5-10 years), with possible full-scale production beyond this time period (beyond 2030). Sasol is the chief producer of fossil-based hydrogen in the country and has embarked on a number of initiatives and collaborations in order to invest in green hydrogen production. This takes the form of supplementing existing grey hydrogen production with green hydrogen at its operations as well as initiatives with other companies in order to create new value chains. In April 2021, Sasol announced a partnership with Toyota to assess the feasibility of developing a green hydrogen mobility ecosystem in South Africa. [6] At the same time, Sasol announced a collaboration between Sasol, Linde (Afrox's parent company), Enertrag, and Navitas to bid for the production of sustainable aviation fuel at Secunda to export to Germany. [7] Sasol has also formed a partnership with the IDC for developing the green hydrogen value chain, which consists of developing upstream and downstream markets. Another key industry partner that allied with Sasol's hydrogen production is Air Products, which sources hydrogen from Sasol's operation and refines hydrogen to the specifications of downstream markets that include platinum refining, glass manufacturing and food processing.

No green hydrogen downstream currently exists in South Africa. The existing value chains that can benefit from electrolysers include consumers within the petrochemical downstream that currently use beneficiated hydrogen products such as methanol and ammonia. These include plastics, rubber, fertilizer and explosives value chains. Green hydrogen also feeds into the iron and steel value chains. There is also the potential for new market formation around power generation, heating and transport. Fuel cell markets do exist; however, they are currently focused on specific applications such as telecommunications backup power.

[6] Sasol, "Sasol and Toyota South Africa Motors Form Green Hydrogen Mobility Partnership." (2021)

[7] Sasol, "Sasol to Explore Potential of Cleaner Aviation Fuels with World Class Partners." (2021)

Vodacom, for example, has 300 fuel cell units, which provide backup power to its base sites. [8] Major future demand is also anticipated from fuel cell mobility solutions, where the local deployment of heavy-duty fuel cell forklifts and trucks by firms such as Impala Plats and Anglo Platinum are underway. Other energy sector participants have indicated an interest in integrating their operations with hydrogen production. Eskom has begun looking at the decommissioning of the existing coal fleet and repurposing the power stations in line with the just transition narrative. As part of this process, green hydrogen is being investigated as an energy option for deployment at the power stations.

In October 2021, the DSI released a report on the potential of a hydrogen valley to catalyse the growth of the green hydrogen value chain, leveraging existing policies such as the Renewable Energy Independent Power Purchasing Programme (REIPPP) and the Renewable Energy Development Zones (REDZs). Three hubs were identified to originate the valley and include Johannesburg, Durban/Richards Bay, and Mogalakwena/Limpopo based on future demand, good renewables and water conditions, and the potential for just transition policies, given their proximity to vulnerable groups. [9] Based on the valley concept, the expected demand in these hubs is anticipated to be up to 185 kilotonnes of H_2 by 2030, consisting of a mix of chemicals production, iron and steel, heavy- and medium-duty trucks, oil refining and exports. The report identifies nine catalytic projects to stimulate production and demand with further scaling upon success. Four projects target mobility with bus conversions to fuel cells, heavy-duty trucks, forklifts, and refuelling infrastructure throughout the country. Two projects target chemicals production of ethylene and ammonia in Sasolburg. Finally, two projects target backup power fuel cell applications in the Limpopo Science and Technology Park and at the Anglo-American offices in Rustenburg. The hydrogen valley is estimated to create between 14 000 and 30 000 jobs per year based on the modelling outputs of the study.

Other domestic developments target green hydrogen and green ammonia near port infrastructure. In October 2021, Sasol announced its signing of a Memorandum of Agreement (MOA) with the Northern Cape Development Agency (NCEDA) to assess the

[8] Engineering News, "CHEM to Set up South Africa's First Fuel Cell Factory in the Dube TradePort." (2019)

[9] DSI et al., "South Africa Hydrogen Valley Final Report - October 2021." (2021)

feasibility of exporting green hydrogen and ammonia from the Boegoebaai port. The feasibility will determine the scaling up of the project to commercial scale and is anticipated to be a two-year process. [10] A further green ammonia project was announced in January 2022 at the port of Coega in the Eastern Cape. Linde and Hive Hydrogen, have embarked on an R75-billion green ammonia export plant in Nelson Mandela Bay, which is anticipated to create 100 000 jobs. [11] The first project is anticipated to begin in 2025.

In February 2022, the DSI released the Hydrogen Society Roadmap which identifies four catalytic projects - the Hydrogen Valley Initiative (detailed above), CoalCO2 -X project, Boegoebaai SEZ (detailed above) and the Sustainable Aviation Fuels Project (detailed above). The CoalCO2 -X project aims to channel funding towards projects that use green hydrogen and pollutants (e.g. CO, SOx, NOx) contained in the flue gas from coal-fired boilers to make value-added products.[12] Near terms, product opportunities include sulphuric acid and fertiliser production. DSI has allocated R50 million into research and development within the programme.

The evolution of skills demand

Previous research and analysis work on the industry consultation within the UK-PACT project has revealed the likely skills that will be required by the industry in the coming decades to support domestic green hydrogen value chains.[13] The insights from that work are highlighted below.

At the input manufacturing stage, new infrastructure is being set up by firms such as Isondo Precious Metals, HyPlat, Chem Energy SA, and Bambili Energy. On the back of these investments, increasing demand for artisans and technicians is anticipated. Operations activities generally take up technicians and artisans and involve assembling and producing

[10] Sasol, "Sasol Announces Lead Role in Feasibility Study for the Boegoebaai Green Hydrogen Project | Sasol." (2022)

[11] Creamer, "Mining Weekly. Formal Launch of South Africa's First Green Ammonia Project on Tuesday." (2022)

[12] DSI, "Hydrogen Society Roadmap for South Africa 2021." (2021)

[13] TIPS, "Working Paper: Industry Demand for Green Hydrogen Technician and Artisan Skills (Publication Forthcoming)." (2021)

of finished products. The roles of artisan and technicians at this stage will involve new job roles and will require new sets of training requirements and programmes to be developed. These might include new roles and skills based on the market engagements and sense-checking against existing roles within firms. Training currently occurs in-house where firms hire artisans and technicians and provide the necessary skills to contribute to operations. HyPlat, for example, currently trains artisans in-house with respect to catalyst preparation, coating, gasketing[14] and Gas Diffusion Layer[15] (GDL) application and packaging. Isondo Precious Metals is soon embarking on scoping artisan and technicians for deployment into their operations. Bambili Energy is also investigating the roles of artisan and technicians in its manufacturing operations and has already trained TVET graduates to operate and maintain hydrogen fuel cells at 1 military hospital.

Existing firms that produce hydrogen via the fossil fuels-based routes have indicated intentions to introduce green hydrogen production into their processes. Once operations have commenced, demand for technicians and artisans will likely increase given their roles in operations of systems. Many roles already exist within the production process and internal labour will be sought and re-trained and re-skilled for new production roles, before new labour is hired. Technicians and artisans in the existing hydrogen production processes are trained with a combination of TVET training and in-house training. In house training in chemical operations is typically carried out for a period of approximately 12 months. In-house training is required to familiarize employees with production processes and plant operations. Firms are optimistic about training programmes for the hydrogen economy, with some firms already announcing partnerships that involve training for the development of the hydrogen economy. Technicians and artisans are trained in skills for chemical operations, millwrights, diesel mechanics, fitting, electrical skills, and fabrication. Hydrogen-producing firms already use the TVET colleges for training purposes and will continue to do so as green hydrogen activities increase. It is estimated that many of the current roles will be able to be repurposed for hydrogen production and that the existing skills base at the production stage will not require a substantial overhauling.

[14] Gasketing refers to the process of installing gaskets in a fuel cell system. This prevents potential fuel leaks and improves efficiency.

[15] Gas Diffusion Layers are vial components of a fuel cell and electrolysers. These layers improve electrical conduction, prevent corrosion and control the mixing of gases.

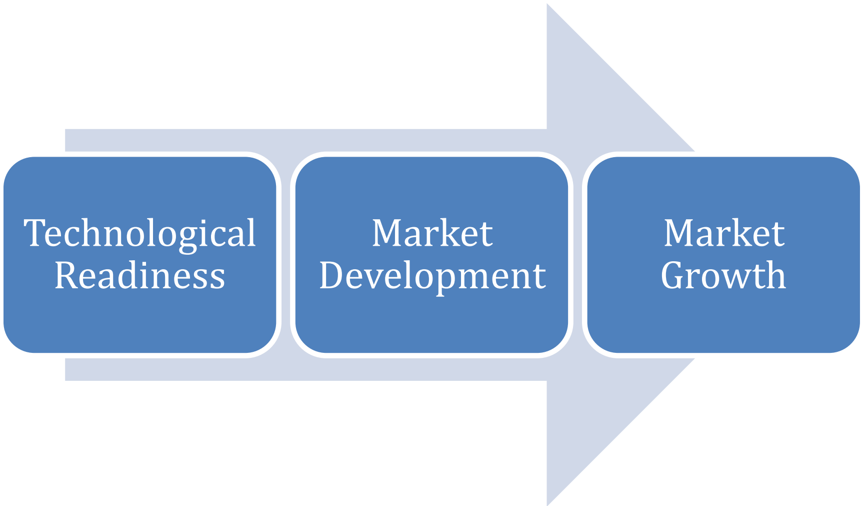
The downstream markets for certain types of hydrogen economy products, such as fuel cells, do exist however these are currently limited and confined to specific applications such as backup power systems for telecommunications. There are no current markets for green hydrogen downstream products as green hydrogen is not commercially produced in South Africa currently. As new markets evolve it is likely that new roles for technicians and artisans will appear. Job roles emerge in a number of value chains, which include the automotive, heavy-duty transport, maritime, aviation, and power generation value chains.

Stages of markets and development

It is important to distinguish the stage of development a country is at and the extent to which green hydrogen already exists. Most countries globally are at the beginning of their respective green hydrogen pathway development and will face various stages of development which imply a focus on different types of policy support.

IRENA (2021) distinguish three phases of development for green hydrogen which aid in understanding where the focal points of policy should lie – technological readiness, market penetration and market growth. The features of each stage are indicated below.

Figure 1. Stages of green hydrogen market development



Source: TIPS, based on IRENA [16]

Table 1. Stages of market development in green hydrogen

Stage	Features
1. Technological readiness	• No cost parity with grey hydrogen • Electrolyser production at the MW stage • Increased renewable penetration necessary • Selected niche applications identified for hard-to-abate sectors • Small volumes of green hydrogen produced • Transport through trucks as pipeline infrastructure absent • Co-location of electrolysers and centres of demand likely to mitigate transport costs • Storage typically occurs on-site with some testing of underground storage (e.g. in ports) • Countries engage in bi-lateral agreements to secure supply/demand for future investments
2. Market penetration	• Cost difference between green and grey hydrogen declines substantially • Electrolysers at the GW scale

[16] IRENA, "International Renewable Energy Agency. Green Hydrogen Supply: A Guide to Policy Making." (2021)

	• Broad renewable deployment • Industrial modifications to take pure hydrogen supply • Proliferation of demand centres (e.g. hydrogen valleys) • Increased viability of pipeline and ship transport for larger volumes • Conversion of gas networks to transport hydrogen • Bilateral agreements result in new trade routes
3. Market growth	• Cost parity with grey hydrogen • Substantial reduction of emissions in the energy sector • High share of wind and solar generation in energy system • Hard-to-abate sectors further reduce emissions • Diversified user markets with competitive supply and global trade

Source: IRENA[17]

South Africa is at the earliest stage of the market development, with a number of R&D initiatives through the HySA and DSI programmes, as well as recent interest in green hydrogen from private sector participants at various stages of the value chain. This is further supported by the fact that all projects to date are aimed at the pilot scale and green hydrogen production still remains costlier than the incumbent grey hydrogen produced. The value chain has yet to be developed and sufficient market demand is absent. With the Hydrogen Society Roadmap having just been publicly released in February 2022 and with national departments still investigating their role in the support of green hydrogen, this adds further support to the positioning of South Africa at the technological readiness phase.

The stage of development has implications for skills development, job creation and employment. Given the nascent value chain, skills development and job creation is likely to materialise based on technologies to reduce the cost differential with existing grey hydrogen production. Here the focus would concentrate on input manufacturing of electrolysers and fuel cells, and integrated renewable energy systems with jobs in targeted and niche downstream sectors that have been identified as low hanging fruit. These downstream

[17] IRENA.

sectors include value chains such as sustainable aviation fuel and green ammonia for example. As the market grows, new roles are likely to appear in new downstream sectors such as e-mobility.

Policy tools

Industrial policy

- **Industrial policy tools**

Industrial policy has a strong role to play in supporting the development of green hydrogen activities particularly given that the market is new in South Africa. Like new and sustainable markets throughout time, the market faces the classic chicken and egg problem - production costs exceed the incumbent grey hydrogen costs which inhibit demand, however, absent sufficient demand, investments remain too risky for wide-scale production that could drive costs down. Industrial policy is vital, particularly at the early stages of market development where demand is uncertain and the capital-intensive nature of entering the value chain presents a barrier to market entry.

Industrial policy measures that can stimulate manufacturing in green hydrogen include the use of direct financial assistance and fiscal incentives.

Direct financial assistance refers to the provision of subsidies, grants and loans to private sector participants to determine the viability of setting up a manufacturing facility, or to expand an existing manufacturing facility to increase the production of a good or service, or diversify into the production of another good or service. Here a number of countries have provided direct financial assistance to increase the uptake of key manufactured inputs such as electrolysers based on committed targets for electrolyser capacity, for example. These include subsidies for pilot programmes and other R&D types of funding. Many countries have included assistance for the development of hydrogen value chains as part of Covid recovery stimulus packages. This is estimated at an aggregate of approximately USD 20 billion. [18]

Fiscal incentives refer to support that is provided to new entrants or existing producers to encourage green hydrogen equipment manufacturing or production. This support reduces the costs of investments and strengthen the business case for investment.

[18] IRENA.

Table 2. Types of fiscal incentives for green hydrogen development

Type of incentive	Mechanism of action
Carbon Tax	Taxation linked to the quantity of carbon emissions which increases the costs of fossil-based hydrogen
Capital subsidy, Grants	Payment to cover a fraction of the capital cost of green hydrogen Investments
Feed-in Tariff or premiums	Purchase agreement for the sale of renewable electricity which is linked to the cost of production and where the price is set above the market price.
Loan guarantees	Guarantees permitting lenders to claim back from the state a proportion of the principal amount and accrued interest on a loan that may go into default
Production tax credit	A tax credit mechanism which provides an income tax rebate to a hydrogen producer/manufacturer in proportion to the quantity produced for a specified period of time
Investment tax credit	A tax credit that provides an income tax rebate based on the capital investment volume
Reduced excise taxes	Consumption tax exemptions/reductions on the sale of qualified products
Accelerated depreciation	Depreciation used for income tax purposes allowing greater deductions in the earlier years of the life of an asset
Soft loans	State loans with preferential terms to reduce the costs of capital including lower interest rates and longer loan terms

Source: Talebian et al., 2021

After Australia launched its National Hydrogen Strategy in 2019, the Federal Government developed a funding package to grow the hydrogen industry in the country. This involved ring-fencing funding streams within the Clean Energy Finance Corporation (CEFC) and

Australian Renewable Energy Agency (ARENA) for AUS$ 370 million.[19] The CEFC funding allocated AUS$ 300 million for new hydrogen projects through concessional financing, while the ARENA funding allocated AUS$ 70 million for catalytic electrolyser projects.

Chile has also embraced financial support as a means of growing the market. The Chilean Economic Development Agency (CORFO) has allocated in excess of $200 million of funding for green hydrogen projects and promoting innovation and research key industries. The funding is channelled towards grants for projects in the pre-feasibility and engineering study phases under CORFO's Innova High Technology Program.[20] The identified initiatives include conversion of mining vehicles to fuel cells, green ammonia production, and green mining. The support package also includes tax benefits that are tied to the use of hydrogen-powered electric vehicles, which will likely include tax deductions for the purchase of a vehicle or the cost of green hydrogen-based fuel. Other incentives under consideration include increasing the current carbon tax rates on the use of fossil fuels, eliminating fossil fuel subsidies to the freight and transportation industries, and providing a temporary tax holiday for green hydrogen. In January 2022, Chile announced the channelling of $50 million towards six identified projects.[21] These projects include the production of green hydrogen, e-methanol, and green ammonia for the export market.

Support for green hydrogen value chains is also being viewed as conduits in which to enact just transition policies and channel financial assistance. In the EU, the Just Transition Fund makes allowance for the support of clean energy projects in impacted regions. [22] The Just Transition Fund is the 1st Pillar of the Just Transition Mechanism (JTM), which is part of the European Green Deal to create a climate-neutral economy in Europe by 2050. The fund has available €17.5 billion of funding to be disbursed through grants, procurement and financial instruments to all EU countries energy transition-impacted regions being prioritized. The fund will consider new green hydrogen projects, modification of existing operations and

[19] Department of Industry, Science, Energy and Resources, "Australia to Be a World Leader in Hydrogen | Ministers for the Department of Industry, Science, Energy and Resources." (2021)

[20] Willkie Farr & Gallagher LLP, "Chile Aims to Win Green Hydrogen Race." (2021)

[21] Jones, "Chile - $50 Million for Green Hydrogen Development." (2022)

[22] EC, "Just Transition Fund." (2021)

support for investments in research and innovation activities, including by universities and public research organisations. [23]

The offering of incentives does require funding from the state, however, the impact of support measures on governments' fiscal budgets may likely be small at the beginning of green hydrogen development, given limited production capacity. [24] Further, sliding fiscal incentives that decrease as capacity is deployed could ensure momentum with the improving economics of the industry.

Energy Planning & Policy

- **Targets**

The setting of targets indicates commitment from policymakers to transition towards cleaner forms of energy. Targets are intended to set a floor with the aim of being surpassed if possible, increasing manufacturing capacity and decreasing long term investment costs. [25] Within the context of green hydrogen, these commitments typically feature in national hydrogen strategies and energy planning. Targets are applied throughout the value chain and aim at renewables capacities, electrolysers, and downstream applications such as targets for FCEVs. The setting of targets allows for the parallel development of renewable generation and electrolysers.

The EU Hydrogen Strategy aims for 6 GW of electrolyser capacity by 2024 (first phase) in Europe producing 1 million tonnes of green hydrogen. [26] This capacity is intended to be deployed close to demand centres such as refineries, steel-making operations and chemical plants and powered by local renewables generation. Further electrolyser capacity is to be deployed at hydrogen refuelling stations which are foreseen to cater to increases demand for heavy-duty vehicles such as buses and trucks. In the second phase (2025 – 2030), the Strategy aims for 40GW of electrolyser capacity with a production volume of 10 million tonnes of green hydrogen. Key to the strategy is the development of clusters or valleys,

[23] EC.

[24] IRENA, "International Renewable Energy Agency. Green Hydrogen Supply: A Guide to Policy Making." (2021)

[25] IRENA.

[26] EC, "European Commission. A Hydrogen Strategy for a Climate-Neutral Europe." (2020)

which link hydrogen supply with consumers in close proximity, which limits transport costs. Member States and private developers within the EU have also committed 30GW of electrolyser capacity by 2030. [27] Chile has also made ambitious commitments for electrolyser capacity in its National Green Hydrogen Strategy, committing to 5GW of capacity by 2025 producing 200 000 tonnes of green hydrogen per year and 25GW by 2030.

- **Exemptions from taxes and levies**

Electrolysis is an energy intensive process, where electricity costs account for a substantial component of the final hydrogen price. As a result, electrolysis projects are typically subject to taxes and levies that are charged to energy intensive users. Taxes and fees can represent a significant share of the final electricity price for industrial consumers, which translate into a higher cost component in the cost of hydrogen. In order to aid price competitiveness of green hydrogen, certain countries have opted to exempt green hydrogen electrolysers from the typical taxes and levies that are charged to energy-intensive users. In Germany, by exempting hydrogen projects from taxes and levies reduces the cost of hydrogen from USD7 per kg to USD2.5 per kg and Germany exempt electrolysers from these taxes and levies. [28] Similar exemptions also feature in Norway, France and the Netherlands. [29] Exemptions are seen as an early catalyst to stimulate the market and are not perpetual. As such policymakers determine a phase out date, a capacity limit for which exemptions apply, and/or a time of day.

Skills development and training policy

- **Technical and Vocational policies**

In order for the green hydrogen value chain to grow and flourish within a country, access to key skills and a workforce is vital in order to develop local expertise and increase domestic employment within the industry. While highly skilled roles that demand tertiary education are

[27] IRENA, "International Renewable Energy Agency. Green Hydrogen Supply: A Guide to Policy Making." (2021)

[28] Clean Energy Wire, "Germany Paves Way for Electrolyser Ramp-up by Scrapping Renewables Fee on Hydrogen Production." (2020)

[29] OECD, "Taxing Energy Use 2019: Country Note – Iceland." (2019)

imperative in the initial stages of a new and highly technological industry, as manufacturing and production begin, the demand for technical and artisan roles[30] will increase.

Australia's National Hydrogen Strategy calls for an emphasis on education and training in order to develop domestic expertise. Among the identified, technical and vocational roles include technicians, gas fitters, plumbers and builders. [31] Australia has set up Industry Reference Committees which consist of industry-led bodies that provides advice on the implementation of national vocational education and training (VET) policies. [32] With an industry-led approach, the Construction, Plumbing and Services Industry Reference Committee has responded to the need for identified skills needs and training programmes by engaging with industrial partners to feed skills needs into training programmes in the VET system. Through the course of analysis, eight new competencies were identified and include: commissioning/decommissioning of electrolyser and fuel cell systems, servicing and maintenance, purging, design and sizing of systems, water treatment, design and sizing of flue systems, hydrogen chemistry, and compression/cooling of hydrogen. [33] Through this identification, hydrogen units of competency will be set up and plumbing and gas qualifications in the VET system will be updated to reflect green hydrogen education and skills. In a similar manner, other Industry Reference Committee's are reviewing and updating their training packages to be hydrogen-ready. The Austalian government has indicated that all training will filter through occupational licensing regulators to ensure updated training will lead to appropriate licensing. Australian states have also formulated action plans for the development of green hydrogen. South Australia's Hydrogen Action Plan, for example, aims to leverage its $200 million Skilling South Australia initiative to develop apprenticeships and vocational qualifications for skills within green hydrogen. [34]

---

30 Technicians and artisans are used to cover the breadth of low skilled and semi skilled roles which can also include operators, workshop assistants, installation and maintenance assistants etc.

31 COAG Energy Council, "Australia's National Hydrogen Strategy." (2019)

32 AISC, "Australian Industry Skills Committee. About the AISC." (2021)

33 Artibus Innovation, "Exploring Hydrogen Skills Needs in the Plumbing and Gas Industry." (2021)

34 Government of South Australia, "South Australia's Hydrogen Action Plan." (2021)

In the EU, technical and vocational training are regarded as supportive of the just energy transition and covid recovery. [35] While not exclusively focused on green hydrogen, the Osnabrück Declaration on vocational education and training identifies key actions to improve VET systems in Europe in order to prepare countries for future green industries. [36] Here key policy interventions are proposed at the EU and member-state level over the period 2021-2025. Interventions for support focus on improving resilience and excellence, establishing a new lifelong learning cultures, improving sustainability, and the international dimension of support. Key interventions in the declaration include: increased use of digital learning platforms, a greater emphasis on work-based learning, improving the responsiveness of VET institutions to changing demands and updating curricula timeously, skills intelligence systems that include graduate tracking, career guidance, training entitlements, and re-skilling of the workforce due to the transition. Another vital policy intervention within the EU context is the setting up of Centres of Vocational Excellence (CoVEs) that pool vocational education and training centres, employers, research centres, development agencies, and employment services. CoVEs aim to create skills ecosystems that contribute to regional, economic and social development, innovation, and smart specialisation strategies.

Box 1. Updating the VET system in the EU

TheErasmus+ Programme is an EU student exchange programme. The programme funded a project called project SolarCV where between 2015 and 2018, that aimed to increase the capacity within the VET system to the growing demand for solar concentrated solar power (CSP) skills.

The programme employed innovative learning approaches that included an e-learning platform, with an e-simulator, along with training materials for formal VET training on CSP. The e-simulator used e-learning with advanced teaching methods based on real world plant operation scenarios. The programme was used to develop a competency profile and skills standard applicable at the EU-level. 16 organisations from five EU-Member States participated in the project, including solar energy VET experts, national sectoral

[35] EC, "European Commission. Commission Staff Working Document Accompanying the Proposal for a Council Recommendation on Ensuring a Fair Transition towards Climate Neutrality." (2021)

[36] CEDEFOP, "European Centre for the Development of Vocational Training. Osnabrück Declaration on Vocational Education and Training as an Enabler of Recovery and Just Transitions to Digital and Green Economies."

associations, energy agencies, government representatives in the field of qualifications, and two EU umbrella institutions. [37] A similar structure can be applied to green hydrogen value chains in order to increase the supply of appropriately-qualified technicians and artisans.

Germany, in its National Hydrogen Strategy specifically highlights the need for the development of technical and vocational skills. Specific emphasis is placed on the staff that produce, operate, and do maintenance work. [38] These include plant manufacturing staff and staff in downstream markets such as fuel cell electric vehicle (FCEV) garage staff. An important intervention within the strategy is the creation of centres of excellence at non-university research institutions and institutes of higher education. Fostering international capacity also features with support for technical and vocational training in export markets.

A just transition is crucial for delivering a sustainable hydrogen society in South Africa. The recent launch of the South Africa Hydrogen Society Roadmap is expected to accelerate and become a model for the country's green energy transition towards a sustainable workforce that is inclusive and green growth-oriented. First, there is a need to both employ the current estimated 33% of TVET graduates that are unemployed in South Africa,[39] while also strengthening the TVET college system to train many more graduates to enter the workforce. Second, addressing the critical skills gap between industry demands and the public college offering remains a key imperative. Third, the net increase in jobs created in the hydrogen economy will include some job losses. DSI envisages the establishment of a Just Energy Transition Centre that will "focus on re-skilling marginalised communities to take up opportunities in new and emerging energy areas, such as hydrogen and fuel cells, batteries, carbon capture and use, and RE technologies."[40] It is anticipated that the centres will be proximal to expected regions where job losses are likely to materialise, e.g. Emalahleni, Secunda and other appropriate municipal regions in Mpumalanga province; as well as other affected regions within South Africa. The centre is expected to conduct studies with relevant

[37] EC, "European Commission. Commission Staff Working Document Accompanying the Proposal for a Council Recommendation on Ensuring a Fair Transition towards Climate Neutrality." (2021)

[38] Federal Ministry for Economic Affairs and Energy, "The National Hydrogen Strategy." (2021)

[39] StatsSA. P0211 - Quarterly Labour Force Survey (QLFS), 4th Quarter, (Statistics South Africa, 2016), http://www.statssa.gov.za/publications/P0211/P02111stQuarter2016.pdf

[40] DSI, "Hydrogen Society Roadmap for South Africa 2021," Department of Science and Innovation, (Pretoria, February 2022).

research chairs to predict market demand for the skills and to inform policy to respond with appropriate interventions.

Table 3 points to the South African TVET policy mechanisms that are currently in place and emerging approaches to improve skills governance policies.

Table 3: South African TVET Policy Mechanisms

Policy	Mechanism of policy	Regulated by	Responsible Authority
Skills governance framework policies	Skills anticipation and matching systems.	• National Skills Authority • Human Resource Development Council (HRDC)	• DHET • SETAs • NDLAC
Sector skills plans	Skills needs assessments to the SETAs that enables aggregation of data	• SETAs • Private Sector	• SETAs
Labour market information/ Skills intelligence/ Skills matching	Forecasting for demand-side data projections is planned to be undertaken as part of the LMIP. The LMIP phase 1 did undertake projections of both skills supply and demand as well as mismatches between the two. Supply-side projections for TVET colleges universities are currently undertaken by DHET as part of the enrolment planning processes.	• Skills Development Act • White paper for Post School Education and Training (PSET) • Labour Market Intelligence Programme (LMIP) • SETAs • Artisan and Technician Development Technical Task Team (ATD-TTT)	• DHET • SETAs
National Skills Development	A roadmap for the development and reinvigoration of post-school education and training and an implementation framework for the policy goals until 2030.	• National Skills Development Plan (NSDP) • National Plan for Post-School Education and Training (NPPSET) • White paper for Post School Education and Training (PSET)	• DHET • SETAs

Skills Funding	To grow and diversify the sector, based on revised funding norms and standards, e.g., colleges largely provide for students from poor families, and need to differentiate between rural and urban colleges, and between colleges at various stages of development. The integration of the National Skills Development Strategy III and the new National Skills Development Plan into the National Plan is part of the creation of a common funding strategy.	• Medium-Term Strategic Framework (MTSF) • National Skills Fund (NSF) • Skills Development Levy • National Student Financial Aid Scheme (NSFAS)	• National Treasury • DHET • SETAs
Economic Recovery	Skills Strategy to respond to the Economic Reconstruction and Recovery Plan (ERRP).	• National Development Plan (NDP) 2030 • National Skills Development Plan (NSDP) • Economic Reconstruction and Recovery Plan (ERRP)	• National Treasury • DHET
Skills Foresight and Skills Anticipation	No formulated plan or strategy	• National Development Plan (NDP) 2030 • National Skills Development Plan (NSDP) • Economic Reconstruction and Recovery Plan (ERRP) •	• DHET • SETAs
Monitoring and Evaluating the medium- to long-term impact of training programmes.	Tracer studies or graduate tracking surveys are an invaluable tool for monitoring and evaluating the medium- to long-term impact of training programmes. The DHET, through INDLELA, also undertake tracer studies of students who completed a trade certificate. Not currently embedded in the system.	• National Development Plan • National Artisan Development program •	• DHET • SETAs • National Artisan Development Centre

Health and Safety	All colleges must comply with normal health and safety standards as inspected by the Department of Labour. No current health and safety regulations for hydrogen training programmes and site readiness.		• DHET • SETAs

Source: SAIIA

The EWSETA plays an important role in the just transition to the future green hydrogen economy. Their current approach to skills governance is to organise stakeholder engagements that include both online and offline platforms through engagement sessions using SDF roadshows, stakeholder events, CEO roadshows and other collaborations with the industry. EWSETA is currently engaged in a process of establishing an Energy and Water Chamber and developing similar forums to ensure continual triangulations in their labour market research.

SETAs use the Workplace Skills Plan (WSP) and Annual Training Report (ATR) as the quantitative methodology to collect data about skills needs from employers. SETAs only report on the amount of graduates they are likely to train and this is aggregated in terms of emerging demand but it is not based on future planning. SETAs also conduct annual interviews with employers to obtain insight into future skills needs. SETA's make grants available for addressing priority skills needs for which employers apply.

While the current TVET policy mechanisms are comprehensive in addressing TVET-industry demand and supply-side issues, in practice there remains a wide chasm between TVET graduates and the throughput of these graduates into employment. The chasm is a function of incoherence in the PSET system (or what is loosely referred to as the vocational skills system). There is a fundamental disconnect between the TVET system and the skills system and in the interface between the two which is why TVET students are not able to transition into the labour market. The key is the inability of TVET students in terms of their access to workplace-based learning which is an important first foothold in the labour market. The majority of training should be happening in the workplace, not in the college. The TVET-

Industry Gaps Skills Analysis provides insights into the reasons for the current issues.[41] A missing area of policy formulation and development in the policy mechanisms are skills foresight and anticipation policies. DHET and the TVET college system has got a strong record using forecasting methods, but they can be limited in their potential to provide in-depth information on specific emerging technologies, changing job profiles and skill needs in key economic industries. Traditionally, forecasting skills supply and demand have been done using the 'manpower planning approach', in which data from past and current workforces (and populations) are collapsed at the occupation and sectoral level, and predictions on how this will evolve in the future are then made. Though the results produced are useful, this methodology has its limitations. Strengthening skills governance is dependent on the adoption of participatory skills anticipation methods and tools, most notably skills foresight.

- **Skills governance, foresight, and anticipation policies**

There is growing recognition globally for the need to utilize strategic foresight in TVET skills governance and anticipation that goes beyond traditional approaches to skills planning that mostly lean on quantitative forecasting.[42] The ongoing skills mismatch between the private sector and TVET college system calls for strengthening of skills governance, - foresight, and - anticipation systems. The European Centre for the Development of Vocational Training (CEDEFOP) describes skills governance as: "the process of putting in place appropriate institutional structures (intermediary, formal or informal, skills bodies), operational processes (regulation, management, financial and non-financial incentives) and dissemination channels (online or offline platforms) that may aid stakeholder interaction and policy reaction based on reliable labour market information signals."[43]

[41] Bambili Advisory, The South African Hydrogen Economy: A TVET-Industry Skills Gap Analysis (SAIIA-UK PACT Working Paper, 2021).

[42] ILO. Using technology foresights for identifying future skills needs, The Moscow School of Management SKOLKOVO's Education Development Centre (SEDeC). (July 15, 2014).

[43] Cedefop. "Skills anticipation methods and practices: Identifying emerging technologies and skill needs for policy." European Centre for the Development of Vocational Training, (Greece, 2018:2).

The process of predicting the future is becoming more complicated and uncertain, especially over longer time horizons. Futurist Jim Dator's first 'Law of the Future' states: '[T]he future cannot be predicted because the future does not exist,[44] therefore humans can only 'use the future' by employing the human faculties of imagination and anticipation.[45] The pace of technological and scientific change in labour markets have rapidly accelerated and therefore analysts and experts have to opt for a diversity of methods and skills assessment approaches to identify and anticipate the emerging labour market landscape.

Table 4 summarises some of the main methods that can be used to gather information on skills needs. Cedefop[46] points to four that are particularly important. Skills assessment and anticipation methods are those that:

a) rely on putting questions to key stakeholders (questionnaire surveys of employer and employee skill needs and experience of technological change);
b) produce quantitative estimates of future skill demands, by extrapolating past trends and modelling expected developments;
c) source big data on new technologies and skills from a variety of online sources (including job portals, CVs, social media, patents, scientific databases);
d) use non-quantitative techniques, relying mostly on participatory stakeholder approaches to gather in-depth information about the state of current and future skill demand and supply.

[44] James A Dator, Jim Dator: A Noticer In Time, Selected Work, 1967–2018 (Cham: Springer, 2019), 3–5.

[45] Riel Miller, ed., Transforming the Future: Anticipation in the 21st Century (London: Routledge Taylor & Francis Group, 2018).

[46] Cedefop. "Understanding technological change and skill needs: technology and skills foresight." Cedefop practical guide 3. European Centre for the Development of Vocational Training , (Luxembourg: Publications Office. 2021:11). http://data.europa.eu/doi/10.2801/307925

Table 4: Tools for carrying out skills assessment and anticipation

Type of activity	Data collected
Descriptive statistics/stock taking	Estimates of overall demand and supply of skills and technology use, often based on collating data from various sources (e.g. sector skill studies)
Quantitative Forecasting	Forecasting or projecting future demand for skills, typically using econometric modelling
Skills and jobs surveys (questionnaire surveys)	Assessments of demand for, and supply of, skills and technology use, usually with an assessment of the extent to which demand and supply are in balance
Graduate tracer Studies	Using matched administrative data sets or surveys to track people through education and the labour market to see how the former influences the latter
Qualitative research	Use of non-quantitative techniques to gauge in-depth information about current and future skill demand/supply and technology trends, e.g. via company case studies, use of focus groups
Foresight	Critical thinking about the future of skills supply/demand and technology trends, using participatory methodologies
Big data	Use of web sourcing, combined with text mining and machine learning approaches, to collect and classify data about skills, vacancies, technologies, etc.

Source: CEDEFOP classification

An often-neglected area in skills assessments is skills foresight. Skills foresight helps identify emerging technologies of strategic importance to an economy, a region or an organisation and their associated implications for skills. Skills foresight use various futures-informed methods to build futures literacy by means of participatory qualitative data collection and information.[47] These insights provide strategic foresight into the rapid scale of technological change and their impact on skills demand.

Participatory foresight methods enable the discussion on technological change and anticipated skills in cooperation with stakeholders. The participatory approach to skills foresight allows for stakeholders to take co-create and co-design the data generation process. The major distinction between skills foresight and conventional skills assessment methods (such as skill forecasts, skills surveys, big data analyses), is that the latter focuses on producing findings without systematically and fully engaging stakeholders in all stages of the work. The aim with the latter is also to predict future skills demand but predicting skills in conditions of high uncertainty and rapid technological change is highly limited and bound to fail. The usefulness of participatory skills foresight is that it broadens the boundaries of skills perception by:

- identifying new or emerging technologies (trend analysis and horizon scanning),
- assessing the implications of present actions, decisions, etc. (consequent assessment),
- detecting and avoiding problems before they occur (early warning and guidance),
- considering the present implications of possible future events (pro-active strategy formulation),
- envisioning aspects of desired futures (clarity around long-term strategic goals and direction).

It is critical that a common understanding of the conceptual framework underpinning skills foresight should be fostered cross-departmentally within the vocational skills system. The strong focus on the traditional paradigm for skills planning is strangling the vocational training system and needs to be unblocked. This is going to require extensive change management at all levels of the TVET system and must result in a fit for purpose structuring of the system to be able to respond.

Discussion and policy insights

South Africa is at the beginning of its green hydrogen development and a focused policy set of interventions will be required in order to develop the necessary capabilities in order to grow the value chain. A number of encouraging developments are underway with the recent release of the Hydrogen Society Roadmap, along with multi-stakeholder collaborations involving key government departments and the private sector. These include the various

[47] CEDFOP. “Understanding technological change and skill needs: technology and skills foresight.”

initiatives by Sasol, IDC, dtic, and Linde. On the basis of the analysis undertaken for this paper, a set of insights is presented in the various domains of policy.

Green Hydrogen Industrial policy

The dtic has the mandate for enacting industrial policy in South Africa and is the principal department in charge of formulating incentives. There currently do not exist any targeted incentives for the green hydrogen value chain, however, firms entering the green hydrogen value chain have benefitted from support by the dtic in the past. Firms in the input manufacturing space that manufacture components for green hydrogen production, such as electrolysers and fuel cells have benefitted through the dtic's Critical Infrastructure Programme (CIP). The CIP aims to leverage investment by supporting infrastructure that is deemed to be critical and lowering the cost of doing business. Grant offerings are offered as a proportion of total infrastructure development costs up to R50 million. [48] These include assistance for feasibility studies in setting up electrolyser manufacturing facilities. In July 2021, the dtic announced total support of R55 million for feasibility and execution at the Isondo Precious Metals facility in the OR Tambo SEZ which manufactures platinum group metal (PGM) components for the fuel cell and electrolyser industries. [49] In April 2021, Minister Patel announced the formulation of an advisory panel, with the IDC as the secretariat, to develop a commercialization roadmap, targeting catalytic projects in the green hydrogen value chain. The panel consists of partners from the private sector and state departments. State departments consist of DSI (who has led the Hydrogen Society Roadmap), dtic, and DMRE. Various workstreams have been formulated to examine different elements of the green hydrogen value chain development, including legal, policy and regulation, and financial perspectives. The emerging focal points of the advisory panel include: the localization of technologies, the quantum of funding required, the formulation of incentive packages (including tax incentives), skills availability, amendments to legislation, leveraging developmental finance, and apportioning existing funding streams such as the international finance mobilized during COP26. The dtic is currently formulating industrial

[48] dtic, "The Department of Trade Industry and Competition. Critical Infrastructure Programme."

[49] dtic, "Deputy Minister Majola Hails Launch of State-of-the-Art Green Economy Manufacturing Plant – The Department of Trade Industry and Competition." (2021)

policy measures for green hydrogen and examining the extent to which incentives can be accommodated within the current incentives offered by the department.

These developments are notable and industrial policy should seek to intervene appropriately for the stage of South Africa's development. **Incentives should consist of capital grants and low interest/concessional loans in order to reduce the up-front costs of investment into the manufacturing of electrolysers and fuel cell and hydrogen production.** These include allocations for feasibility studies and channeled towards attracting investments into the identified hydrogen valley hubs in Johannesburg, Durban and Limpopo. Additional programmes beyond the CIP such as the Black Industrialist Programme and the Manufacturing Competitiveness Enhancement Programme can also be leveraged as it has been done in the past to support clean energy production. [50] **In order to support the growing demand for green hydrogen internationally, specific export promotion should incentivize hydrogen production proximal to key ports such as Durban, Boegoebaai, Richards Bay and Coega.** This is given South Africa's lack of an extensive pipeline network and to mitigate transport costs.

Given that green hydrogen production depends on renewables-based energy input, the scaling of renewables electricity production will also require policy support. Here the South African Renewable Energy Masterplan (SAREM) is the current policy document supporting the industrialization of renewables in the country. **The Masterplan should be finalized timeously and ensure harmony between renewables generation and the potential for beneficiation through power-to-X technologies used to produce green hydrogen and ammonia. Further, the associated skills requirements should be aligned to ensure alignment and accurate development.**

Green Hydrogen Energy Policy

South Africa's electricity technology mix is planned through the Integrated Resource Plan, with the latest update in 2019. Based on the IRP 2019, no specific targets are set for electrolysers, or electricity from hydrogen, or dedicated renewables generation for hydrogen

[50] Montmasson-Clair and Chigumira, "TIPS - Green Economy Policy Review of South Africa's Industrial Policy Framework." (2020)

production. While IRP (2019) does acknowledge green hydrogen through the mention of fuel cells and the HySA Programme, no specific plans are reflected in the energy mix. Further, given the rapidly evolving cost dynamics in international green hydrogen development**, the IRP (2019) will likely need to be updated to reflect the changing economics of green hydrogen production. The subsequent iterations of the IRP should be developed and aligned with the SAREM in order to coordinate investments into renewables capacity and green hydrogen.**

South Africa also has the Hydrogen Society Roadmap (HSRM) which has been publicly released in February 2022 in development and has identified the setting of targets as a 2021-2024 goal. This will likely take the form of setting targets for electrolysers and production. The Hydrogen Valley report commissioned by DSI has identified other policy interventions and calls for reducing the costs of investments into renewables generation and hydrogen production through capital incentives and the easing of permitting procedures for new projects. **These are supported and further traction can be provided to green hydrogen production through exemptions on electricity taxes and/or redirecting fossil fuel subsidies towards green hydrogen production.** Exemptions will have to be supported by key departments such as dtic, Treasury and NERSA.

Green Hydrogen TVET Skills and Development Policy

On the basis of planned projects and investments, South Africa will require the necessary human capital skills base upon which the green hydrogen value chain will operate. A number of collaborations between key stakeholders will be required in order for the current TVET system to be upgraded and for green hydrogen programmes to be offered. Currently, the TVET curricula require reorientation towards low carbon technologies and green hydrogen in particular. **A particular emphasis should be placed on creating centres of specialisation or hybrid TVET models and should be ideally located proximal to the planned hydrogen hubs in Johannesburg, Durban and Limpopo.** As successful precedent in other countries has proven, TVET systems also need to incorporate innovative learning tools such as e-learning and online simulators to account for learners who are in other geographic regions of the country. The use of online platforms has become even more pertinent due to the prevalence of social distancing during the covid-19 pandemic. The development of curricula has to be demand-led in that curricula should be developed in coordination with industrial players in order to reflect industry dynamics and needs. This philosophy should also be applied to the broader process of TVET development and move beyond the development of curricula in order to develop a system change process that is responsive to the needs of the industry.

SETAs are a further asset of the South African landscape that should be included as the necessary bridge between education and on-the-job training. SETAs in coordination with industry associations and subject matter experts need to be provided with the capacity to formulate skills packages, reinforcing their role as intermediaries between industry and technical and vocational training and education. Institutions in other countries, such as the Industry Reference Committee's in Australia, have formulated skills packages in combination with industry input in order to clearly outline the skills needs and programmes required to prepare future generations for job opportunities within green hydrogen value chains. **Each SETA combined with industry associations and subject matter experts should be empowered to assess their respective sectors in terms of the green hydrogen opportunities that are available within the sector in terms of where they can fit within the value chain.** Based on the identified areas of the value chain, industry participants should be engaged on their skills needs which would then inform the skills assessment for each respective SETA. This should not be a once-off exercise but rather, a dedicated process should be set up with updates to skills needs occurring on an annual basis.

Re-imagining the TVET college system in South Africa will require a shift from a narrow focus on 'jobs' towards a systemic understanding and broader framing of economic wellbeing. When education is reduced to a role that simply services the economy, it leaves the question of meaningful work beyond the formal economy out of the picture, like caring for households, responsible and engaged citizenry that contributes to the common good and creating ecologically resilient lifestyles. Reflecting on broader economic questions like household provisioning, provisioning of the commons, and provisioning of the state, without neglecting paid work in the formal economy, are key to building vibrant well-being economies for human dignity and planetary survival in the future green hydrogen economy.

Skills Foresight, Anticipation and Skills Governance Policy

Harmonise the South African TVET ecosystem strategic framework with regional approaches

The South African Institute of International Affairs (SAIIA), in collaboration with UNESCO Regional Office for Southern Africa (ROSA) Education Unit and the SADC Secretariat, is developing the 'UNESCO-SADC Futures of Education for Higher Education and TVET strategic framework' to build capacities, capabilities, knowledge and co-create a regional response to re-imagining education for sustainable development, education in the digital age, and education in times of crises (COVID-19 pandemic). The development of the SADC Futures of Higher Education and TVET strategic framework employed a variety of foresight/futures tools and planning methods designed to help stakeholders reflect on the strategic trajectory of harmonised higher education and TVET ecosystem in Southern Africa. The DSI and DHET should adopt the UNESCO-SADC Futures of Higher Education and TVET Strategic Framework and develop a country-focused strategic framework that harmonises with the regional framework.

Develop departmental skills foresight capabilities

The analysis of the skills development and training policies in South Africa revealed limited to no use of skills foresight, and qualitative skills anticipation methodologies to better anticipate and prepare for major technological change such as the green hydrogen economy. A key challenge is the capacity of the system to collect, analyse and utilise such data to inform curriculum and programmes. For skills anticipation to work, it requires capacity at all levels of the system, including at the institutional level so that programmes can be developed off the back of this. The DHET, TVET college system and the SETAs should develop capabilities to employ skills foresight, skills scenarios and skills anticipation tools for industrial policy, education and, green hydrogen energy planning – specifically related to technical/vocational skills enhancement and industry absorption. The focus should be on the green hydrogen value chain so that skills planning can look at green hydrogen holistically to integrate lessons learnt through strategic foresight methods, frameworks and participatory stakeholder processes. The development of personnel capabilities across departmental functions will require significant investment in capacity and technology.

Develop skills foresight programmes and pilot projects

The development of the skills foresight policy should enable the implementation of skills foresight programmes among DHET, TVET and SETA skills development staff to improve anticipatory skills governance. To ensure embeddedness of skills foresight and anticipation to ensure better alignment and proactive policy planning the DHET, TVET colleges and SETA's planning staff should build a foresight culture in anticipating and matching skills demand and jobs in the future green hydrogen economy as part of a pilot project to develop these capabilities. DHET should develop mechanisms to translate skills foresight into skills interventions otherwise there will be a continuous gap between policy and implementation.

Develop appropriate skills foresight tools and methods

Part of developing the capabilities to imagine and anticipate futures skills supply and industry demand requires the systems strengthening of foresight methodologies and tools in sectoral approaches to skills anticipation and matching, i.e. the policies and regulations for skills anticipation and matching (competencies and qualifications) in the future green hydrogen economy.

Build anticipatory governance

To ensure the entire approach is embedded in futures literacy capability development the DHET should work with the Centre for Public Sector Innovation (CPSI) to build anticipatory governance to improve green hydrogen skills governance, skills foresight, skills anticipation and skills innovation ecosystems.

Conclusion

A just transition towards a green hydrogen TVET skills ecosystem that enables a transversal skills commons, foster economic wellbeing and ecological resilience by 2050 is achievable. The current juncture requires South Africans to re-envision knowledge and reimagine the purposes of education and the organisation of learning, particularly for providing quality post-school education and training. The desired futures for the TVET skills transition also presents opportunities to embrace digitally enhanced sustainable development within the post-schooling institutions' core functions and build societal capacity for transformative change.

The aim is for marginalised communities to have the autonomy, capacity, resources and skills to become architects of their destinies while at the same time supporting social cohesion and individual well-being. These attributes are critical to ensuring beneficial planetary, human and economic outcomes. Education and skills development institutions are ideally suited to do the required social knitting to create more robust and more resilient communities by providing support and mitigating and removing barriers that prevent individuals from living active and connected lives.

Jan Smuts House, East Campus, University of the Witwatersrand
PO Box 31596, Braamfontein 2017, Johannesburg, South Africa
Tel +27 (0)11 339 2021 • Fax +27 (0)11 339 2154
saiia.org.za • info@saiia.org.za

SOUTH AFRICAN INSTITUTE OF INTERNATIONAL AFFAIRS